BUILDING INFORMATON MODELLING (BIM) MECHANICAL SYSTEMS PLUMBING AND HVAC

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I hereby declare that I have checked this thesis and in our opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Bachelor of Mechatronics Engineering (Hons.).

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I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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Thesis submitted in fulfillment of the requirements
for the award of the degree of
Bachelor of Mechatronics Engineering (Hons.)

Faculty of Manufacturing
UNIVERSITI MALAYSIA PAHANG

MARCH 2017

ACKNOWLEDGEMENTS

Alhamdulillah, all praised to Allah, with all His will, I managed to complete this thesis. I would like to take this opportunity to express my gratitude to all of the people who have help me and to all of the people that involved either directly or indirectly in the realising of this thesis.

First and foremost, I would like to express my deepest gratitude to my supervisor, Dr. Ahmad Fakhri Bin Ab. Nasir who has sacrificed a lot toward the completion of this thesis. His support and motivation has kept me strong during conducting this thesis. Furthermore his insight and guidance, based on his broad experience and knowledge, has allowed me to collect new knowledges while conducting this thesis as well as completing it. Besides that, I would like to thanks my company's supervisor, Encik Zakriman who has share his knowledge and experiences and guide me to complete my thesis.

Not to forget my Hochschule Karlsruhe's supervisor, Prof. Dipl.-Ing. Helmut Scherf, who always spent his time to follow up my work progress and gave a lot of constructive advice and guideline, even he is in Germany.

Second, I would like to express my gratitude to my beloved father, Che Mohd Zulkifli bin Che Mohd Zulkifli, mother, Sharifah Maimunah binti Syed Abdullah and also my siblings as they have been my source of strength, inspiration and motivation in finishing this thesis in the required time.

Third, I would like to express my appreciations to all of my friends who have been involved either directly or indirectly in finishing this project. Without them I would have not be able to finish this project on time.

ABSTRAK

'Building Information Modelling' (BIM) digunakan secara meluas dalam mereka bentuk, simulasi dan menganalisis struktur model bangunan. Ini membantu arkitek, jurutera awam, jurutera mekanikal dan elektrik dan lain-lain untuk gambaran keseluruhan model bangunan sebelum meneruskan pembinaan. sistem mekanikal di dalam bangunan adalah salah satu bahagian yang paling kritikal dalam pembinaan yang terlibat dalam kerja memasang paip dan HVAC sistem. Tham Zamin Bersekutu Consultant merupakan syarikat yang bertanggungjawab bagi pemasangan sistem mekanikal. Pada asasnya syarikat ini merangka sistem mekanikal dalam lukisan 2D dan masalah yang berlaku di tapak pembinaan kerana berlakunya pertempuran antara sistem. Perisian Autodesk Revit diselesaikan ini bertembung masalah dengan model sistem mekanikal dalam 3D untuk bangunan tiga tingkat dan menganalisis pertempuran antara sistem. Untuk menentukan sistem penyejukan di dalam bangunan, jurutera di syarikat ini dikira secara manual dan kaedah ini mengambil masa yang lama untuk disiapkan. Analisis beban haba boleh dijalankan di Revit yang boleh mengatasi masalah ini. Pam bertanggungjawab untuk meningkatkan bekalan air di seluruh bangunan dan saiz pam di bangunan ini perlu dikira juga. Sistem mekanikal pemodelan 3D yang lengkap akan dianalisis dan persempadanan semula model kerana pertempuran berlaku. Selain daripada itu, Program Analisis Setiap Jam (HAP) boleh menganalisis beban haba melalui jam masa dan boleh menentukan keuntungan haba maksimum mengikut struktur dan orientasi dari bilik. Hasil beban haba bagi setiap bilik boleh membuat keputusan Unit Pengendalian Air yang paling sesuai (AHU) bagi bangunan itu. Sistem paip terdiri daripada dua bahagian yang air sejuk dan memadam kebakaran. Pam untuk setiap sistem boleh ditentukan melalui pengiraan dan dua keperluan utama untuk saiz pam adalah kadar aliran dan tekanan. Kehilangan geseran dan kepala statik adalah beberapa faktor yang perlu dipertimbangkan dalam pengiraan. Terdapat peningkatan yang telah dibuat untuk membantu syarikat ini untuk hasil yang lebih baik dalam mereka bentuk dan membuat analisis sistem mekanikal. Pemodelan 3D boleh dipantau untuk mengenalpasti pertembungan berlaku antara sistem mekanikal. Keputusan daripada analisis membawa kepada membuat penambahbaikan dalam pemodelan sebelum meneruskan ke tapak pembinaan. Analisis beban haba yang dijalankan di Revit memberikan hasil yang lebih baik untuk sistem penyejukan.Beban haba maksimum di hotel tersebut ditenentukan dalam analisis ini. Kadar aliran dan tekanan untuk pam telah dikira mengikut faktor dan keperluan yang diperlukan melalui penyelidikan yang telah dilakukan.

ABSTRACT

Building Information Modelling (BIM) is widely used in designing, simulation and analyzing the model structure of a building. This help the architects, civil engineers, mechanical and electrical engineers and etc. to overview the building modelling before proceed to the construction. Mechanical systems in the building are one of the most critical part in construction which involves in plumbing and HVAC systems. Tham Zamin Bersekutu Consultant is the company that responsible for the installation of the mechanical systems. Basically this company drafted the mechanical systems in 2D drawing and problems occurred at the construction site due to clashes between the systems. Autodesk Revit software solved this clashes problem by modelling the mechanical systems in 3D for the three-storey building and analyzed the clashes between the systems. To determine the cooling system in the building, engineers in this company calculated it manually and this method take a longer period to complete. Heat load analysis can be conducted in Revit that could overcome this problem. Pumps are responsible to enhance the water supply throughout the building and the size of the pumps in this building need to be calculated as well. The complete mechanical systems 3D modelling will be analyzed and redrawing the modelling due to the clashes occur. Other than that, Hourly Analysis Program (HAP) can analyze the heat gain through time hours and can determine the maximum heat gain according to the structure and orientation of the room. The result of the heat gain for each rooms can decide the suitable Air Handling Unit (AHU) for the building. The plumbing systems consists of two parts which are cold water and firefighting. The pumps for each systems can be decided through the calculation and two main requirements for the pump sizing are flow rate and pressure. Friction loss and head static are some of the factors need to be considered during the calculation. There are improvements have been made to assist this company for a better results in designing and make analysis of the mechanical systems. The 3D modelling can monitored to identify the clashes occur between the mechanical systems. The results from the analysis lead to make the improvements in the modelling before proceed to the construction site. Heat load analysis conducted in Revit give a better result for the cooling systems. The maximum heat gain in selected rooms were determine in this analysis. The flow rate and pressure for the pumps have been calculated according to the factors and requirements needed through research that have been done.

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LIST OF SYMBOLS

H_t	Pump Head
H_{st}	Static head
H_f	Head loss due to friction
l	Hydraulic gradient
L	Total length of pipe
Q	Flow rate
C	Flow velocity coefficient
D	Pipe diameter

LIST OF ABBREVIATIONS

BIM	Building Information Modelling
CAD	Computer Aided Design
MEP	Mechanical, electrical and plumbing
HVAC	Heating, ventilation and air conditioning
LHDN	Lembaga Hasil Dalam Negeri
AHU	Air Handling Unit
TDH	Total dynamic head
LU	Loading units
HAP	Hour analysis program
BTU	British thermal unit

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

BIM is an acronym for Building Information Modelling and has been defined as "Computer Aided Design (CAD) paradigm" producing a set of interacting policies, processes and technologies generating a methodology to manage the essential building design and project data in digital format throughout the building's life-cycle [1]. Most of the people think that BIM is just another (CAD) program but it actually goes beyond that. In fact it goes well beyond software alone because it is shaping the design process itself. The best way to sum it up is BIM is an architectural process of Virtual Design and Construction that through the heavy use of technology integrates and connects information with the virtual model. As the model is being created, team members are constantly refining and adjusting their portions according to project specifications and design changes to ensure the model is as accurate as possible before the project physically breaks ground [2]. BIM helps some of people working under construction site to understand a building through the use of a digital model which draws on a range of data assembled collaboratively. All of the information regarded to the every component of a building will be combined together in one place by using BIM. Revit, Microstation, Tekla, etc. are examples of BIM software that commanly used by the design team on a project to construct a 3D model and by doing this virtually with it can show all the systems such as architectural, structural, mechanical, electrical, etc. Nowdays BIM software usually used by individuals, businesses and goverment agencies who plan, design, construct, operate and maintain diverse physical infrastructures, such as water, refuse, electricity, gas, communication utilities, roads, bridges, ports, tunnels, etc.

With a shared model in BIM software, there is less need for rework and duplication of drawings for the different requirements of building disciplines. The information that contains in the model have more information than a drawing set, allowing each discipline to annotate and connect their intelligence to the project [4]. BIM drawing tools are faster than 2D drawing tools and each object is connected to a database [3]. This software can do much more of the analysis and modeling to achieve peak performance, condensing knowledge and rules into a service.

In order to construct a building, mechanical, electrical and plumbing (MEP) systems are also important in this field other than architecture, structure, etc. In mechanical systems which more focuses on infrastuctured, plant and machinery, tools and components, heating and ventilation and many else elements that related to it [5]. While in electrical systems might include power supply and distribution, telecommunications, computing instruments, control system, etc. The plumbing aspect focuses on the delivery of water and draining of waste water. Basically MEP is a type of engineering that focuses on the disciplines needed to build safe, working structures for human use and occupation. In mechanical part heating, ventilation and air conditioning (HVAC) is responsible for the installation and maintenance of air conditioning, heating and ventilation and it means changing filters and installing furnaces, along with air conditioners [6]. For some cases, BIM manage to handle tasks such as smoke control and exhaust. For the electrical part, it focuses on switches, lighting, fire alarms, security systems, as well as lighting protection. The plumbing part also handles fire suppression systems and storm pipe systems, as well as gas delivery systems in medical and labotary settings [6].

By using BIM software it can detect any clash occurs when elements of different models occupy the same space. For effective identification, inspection and reporting of interferences in a project model will be ease with the help of clash detection. Basically by using clash detection it will reduces the risk of human error during model inspections and used for checking either completed or ongoing project. In some cases clash detection might be necessary because several models (structural, MEP , etc.) are intergrated into one main BIM model [7]. Clash detection somehow help to prevent mistakes which

normally would have been discover on the site and now it can be done in the office before step into the construction site.

A heat load calculation is a mathematical method of determining exactly how much heating is needed to keep a home or other structure at the indoor temperature level its occupants prefer [21]. Basically, all structures have a heat load and a corresponding cooling load that is based on structural characteristics of the building, steps that have been taken to increase the sructure's energy efficiency, and the comfort preferences of the people who will spend their time in the building [6]. To do an extensive on-site inspections of an existing building or evaluation of plans for proposed construction a heat load calculation need to be conducted.

1.2 PROBLEM STATEMENT

Previously after architects have completed the drawing of a building, MEP engineers will take over the project to design mechanical systems that need to be install in the building. Drawing that have been given to the MEP engineers was in 2D drawing and mechanical systems design will also conducted in 2D drawing. However it will give difficulties to the contractors and several problems occured during the construction of a building. This will effect the time required to finish construct the building and will increase the cost.

Tham Zamin Bersekutu consultant which responsible in designing the mechanical and electrical (M&E) systems in the building received a 2D drawing of the building from the architects. Currently a three-storey building which is Lembaga Hasil Dalam Negeri (LHDN) is conducted by this company. HVAC, fire fighting and cold water which are parts in the mechanical system have been draw in 2D drawing by the MEP designers here and this 2D drawing need to be converted into 3D drawing by using BIM software. HVAC involve in designing for the air conditioning systems of the building while fire fighting and cold water are involves in designing the plumbing systems.

Clash between the mechanical parts always occured after completed the drawing. These clashes between the mechanical systems need to be detected and redraw the

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